Method for Transforming Continuous PM2.5 Monitoring Data for Comparison with the FRM

Michael Rizzo[a], Peter Scheff[b], and William Kaldy[c]

[a]USEPA Region 5, Air Monitoring

[b]University of Illinois – Chicago School of Public Health, Environmental and Occupational Health Sciences

[c]Hamilton County, OH Department of Environmental Services

Data

- Looked at a variety sites from across country
  - All TEOMs
  - Variations in methodology
    - Season
    - Correction factors
- Sites with more than 1 year's worth of data
  - Collocated PM2.5 FRM and continuous method
  - Needed at least 63 samples across entire year to create model and R^2 at least 0.77
    - Based on USEPA DQOs
  - "Surplus" data used to validate model

Data

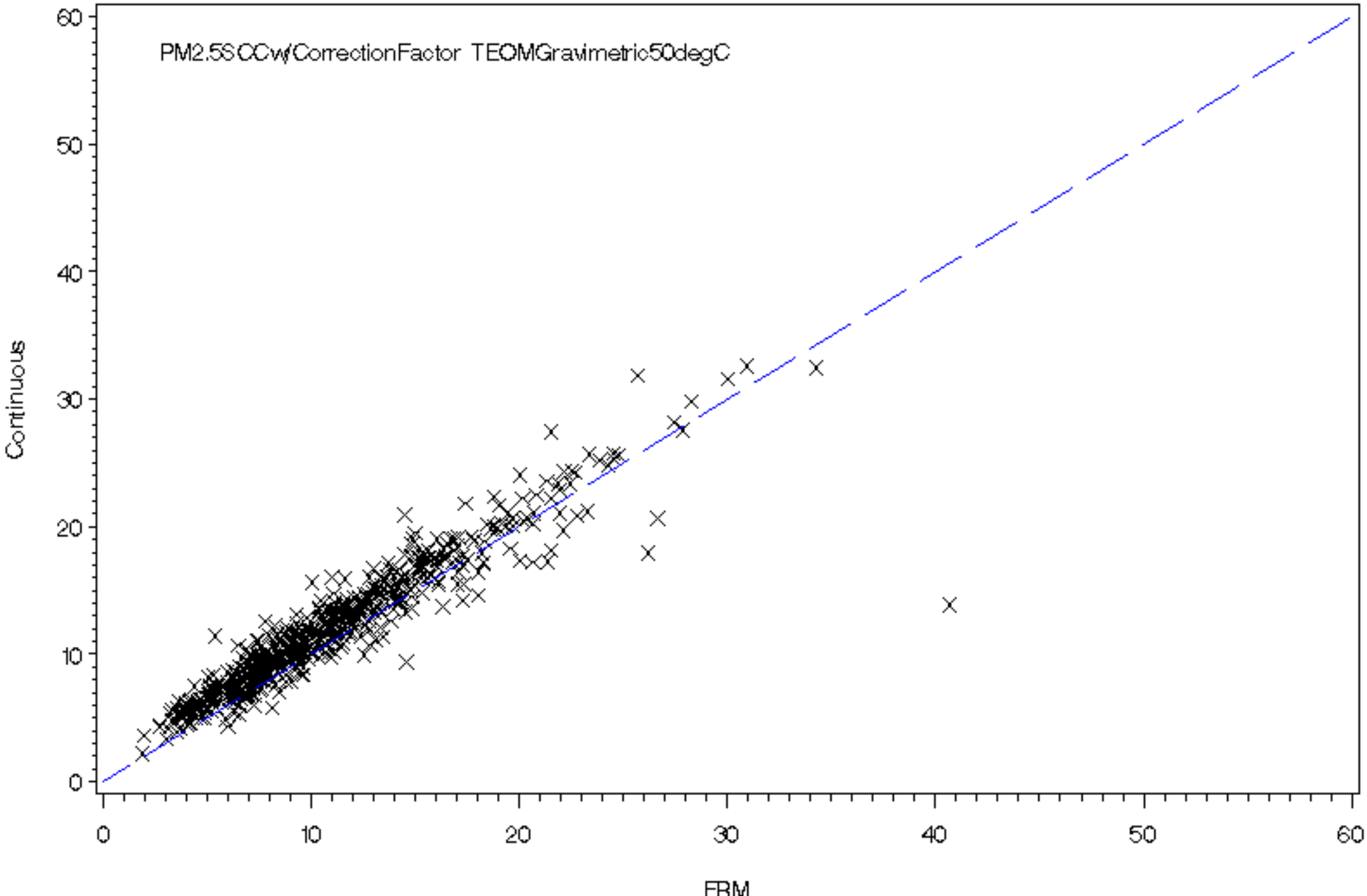
- Valid days had 18 out of 24 hours
  - All variables had to meet requirement
- Model development
  - Hourly PM2.5 averaged over 24 hours
  - 24 hour FRM measurment
  - 24 hour average temperature
    - Collected from FRM monitor

Validation

- National Weather Service temperatures
  - 2000 through 2001
- Closest met station temperatures
  - 2002
- Examined hourly transformations averaged over 24 hours
  - Compared to FRM

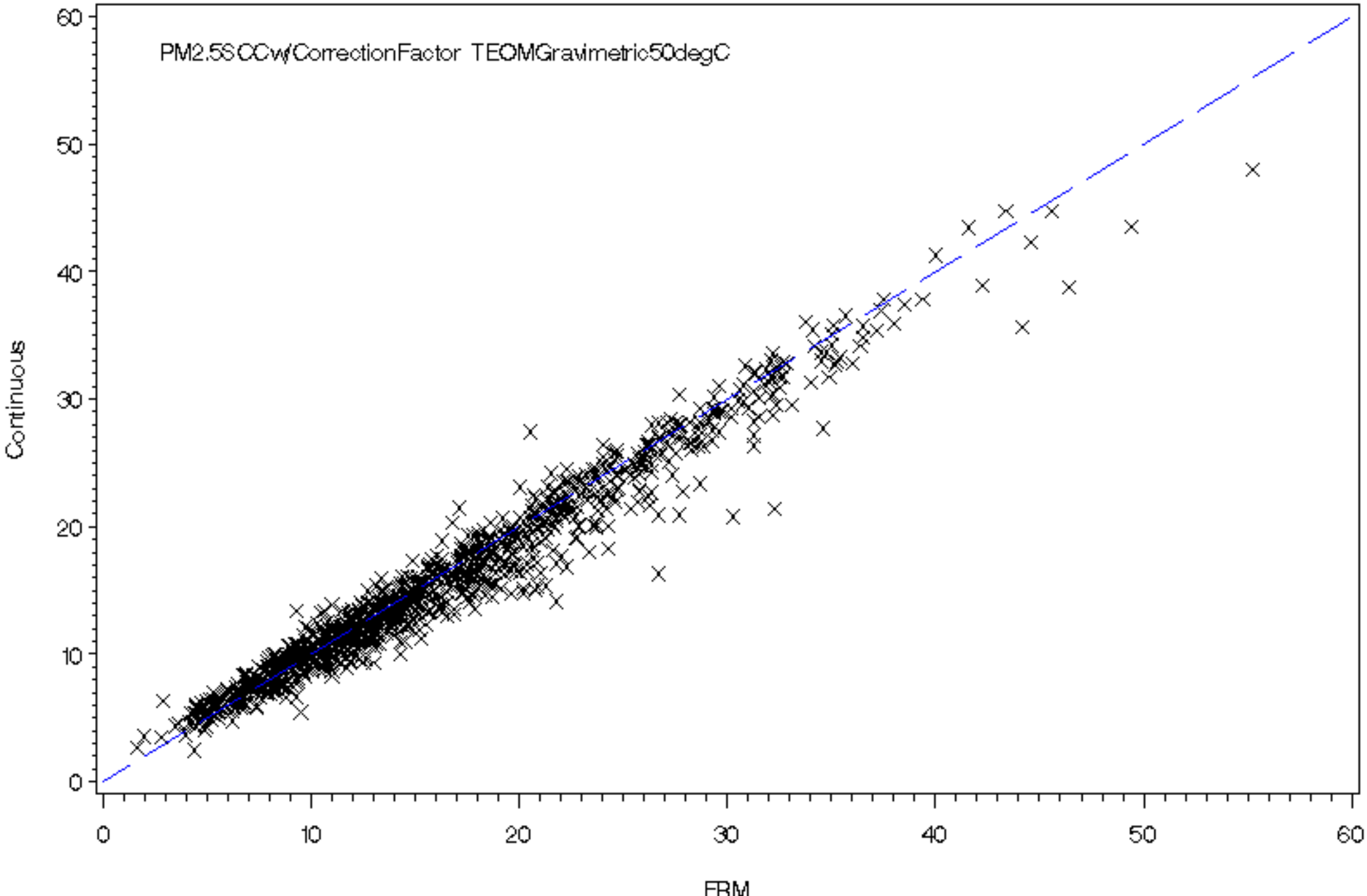
WINTER PARK, FL

120952002881013



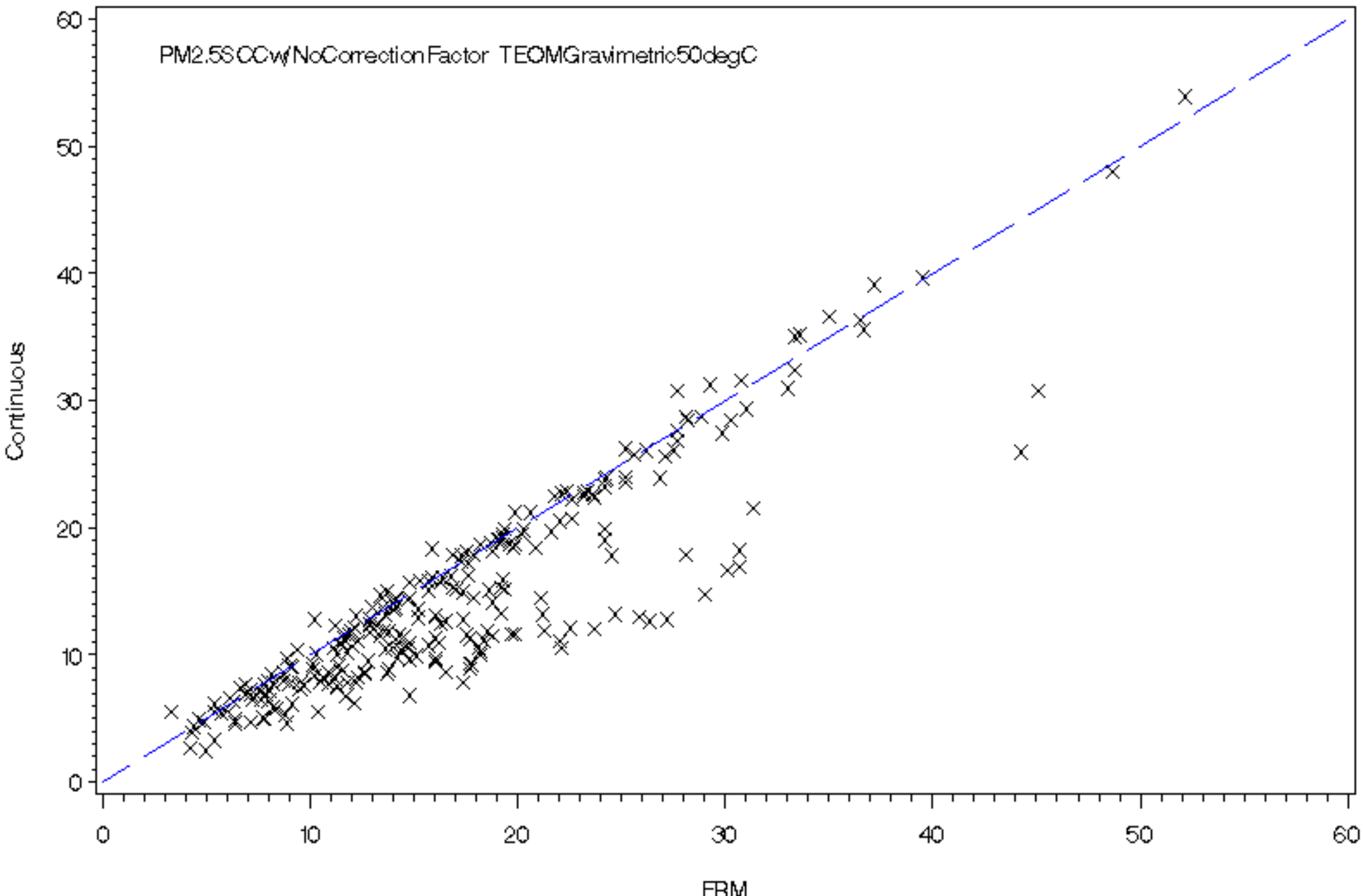
WINSTON–SALEM, NC

37067002281013



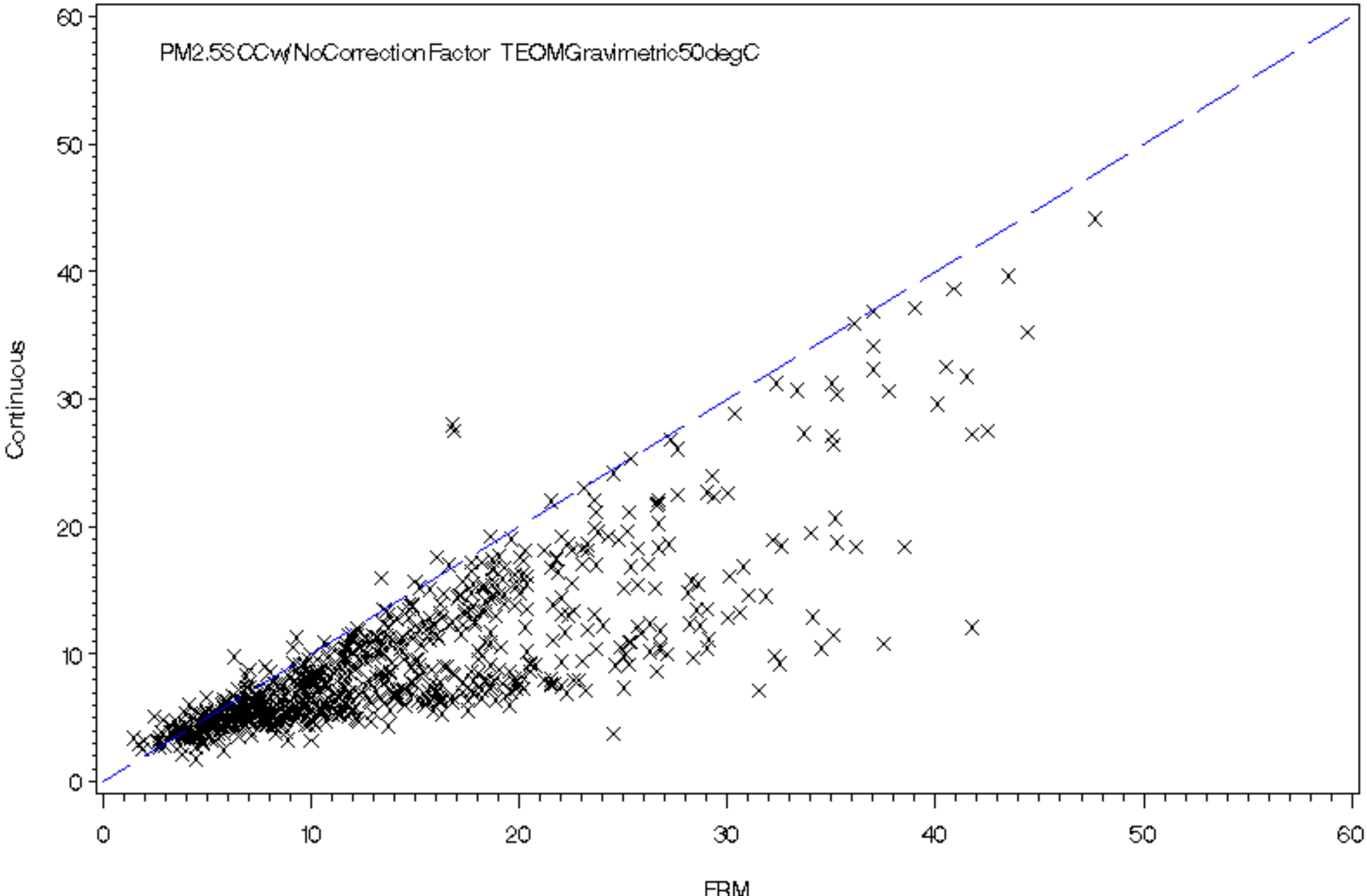
INDIANAPOLIS, IN

180970078681013



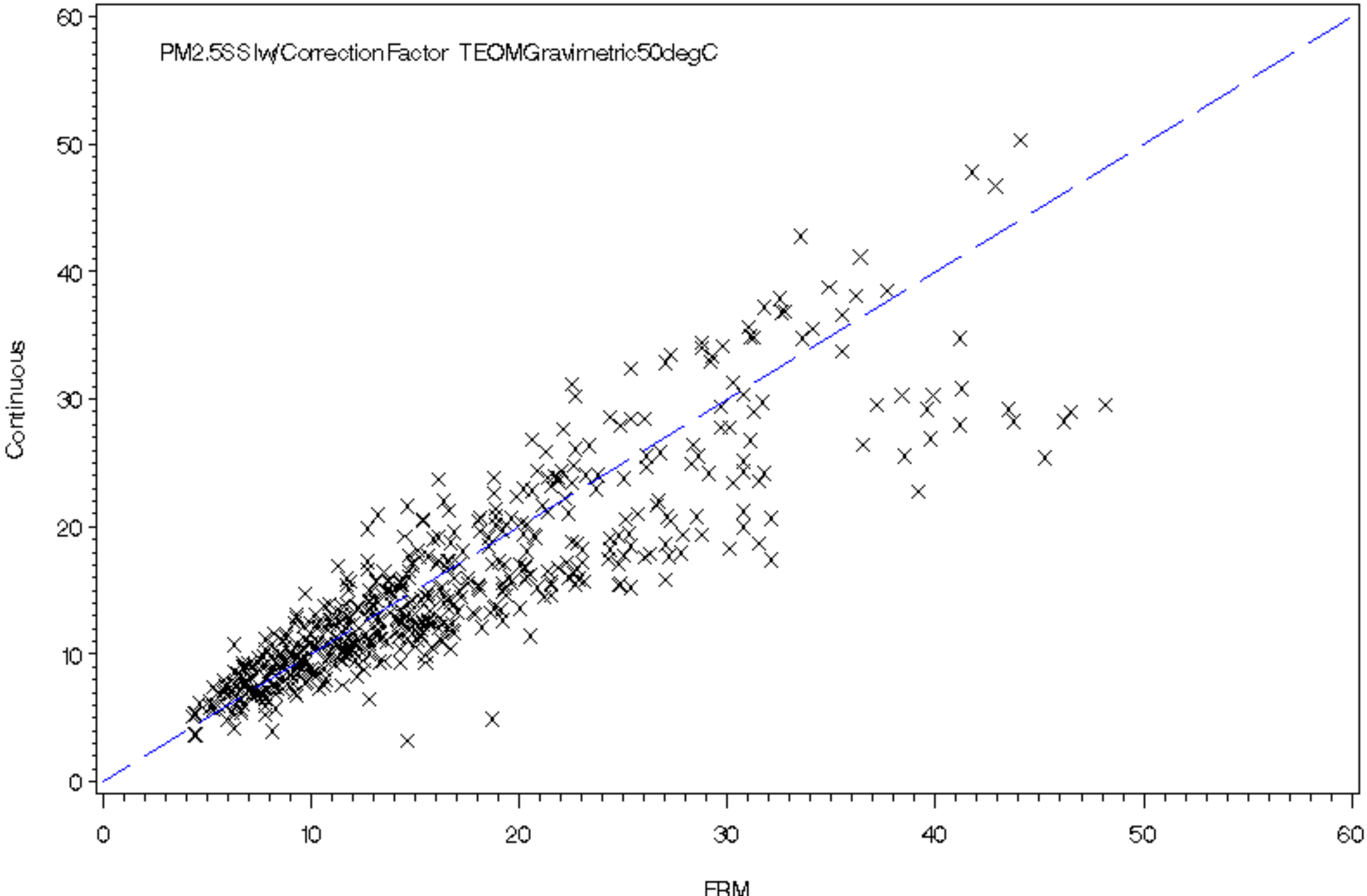
GRAND RAPIDS, MI

260810020681013



NEW YORK CITY, NY

360610010881013



Methodology

"Knot" Method

Equation 1 (*if the temperature is less than the value of the knot*)

$$FRM = \beta_0 + \beta_1*(avetemp-knot) + \beta_3*cont + \beta_4*cont(avetemp-knot)$$

where:

FRM is the Federal Reference Method measurement

β_0 is the intercept

β_1 is the coefficient for the temperature term for temperatures less than the knot

avetemp is the daily average temperature

knot is the temperature at which the linear relationship between the FRM and continuous measurement changes

β_3 is the coefficient for the continuous measurement

cont is the continuous TEOM measurement

β_4 is the coefficient of the interaction between the TEOM and temperature measurements for temperature less than the knot

Methodology

"Knot" Method

Equation 2 (*if the temperature is greater than the value of the knot*)

$$FRM = \beta_0 + \beta_2*(avetemp-knot) + \beta_3*cont + \beta_5*cont(avetemp-knot)$$

where:

FRM is the Federal Reference Method measurement

β_0 is the intercept

β_2 is the coefficient for the temperature term for temperatures less than the knot

avetemp is the daily average temperature

knot is the temperature at which the linear relationship between the FRM and continuous measurement changes

β_3 is the coefficient for the continuous measurement

cont is the continuous TEOM measurement

β_5 is the coefficient of the interaction between the TEOM and temperature measurements for temperature less than the knot

Methodology

- Linear Model
  - FRM = $\beta_0 + \beta_1$*cont $+ \beta_2$*spring + β_3*summer + β_4*fall + β_5*cont*spring + β_6*cont*summer + β_7*cont*fall
  - FRM = Federal Reference Method
  - Cont = 24 hour avg continuous measurement
  - Spring, summer, fall = seasonal variables
  - Cont*spring, cont*summer, cont*fall = interaction terms

Results
"Knot" Model

- Continuous parameter (β_3) usually close to 1
- Temperature>"Knot" interaction term (β_5) usually not statistically significant
- Temperature<"Knot" interaction term (β_4) usually statistically significant
- Knot
  - Median: 15.4^{o} C

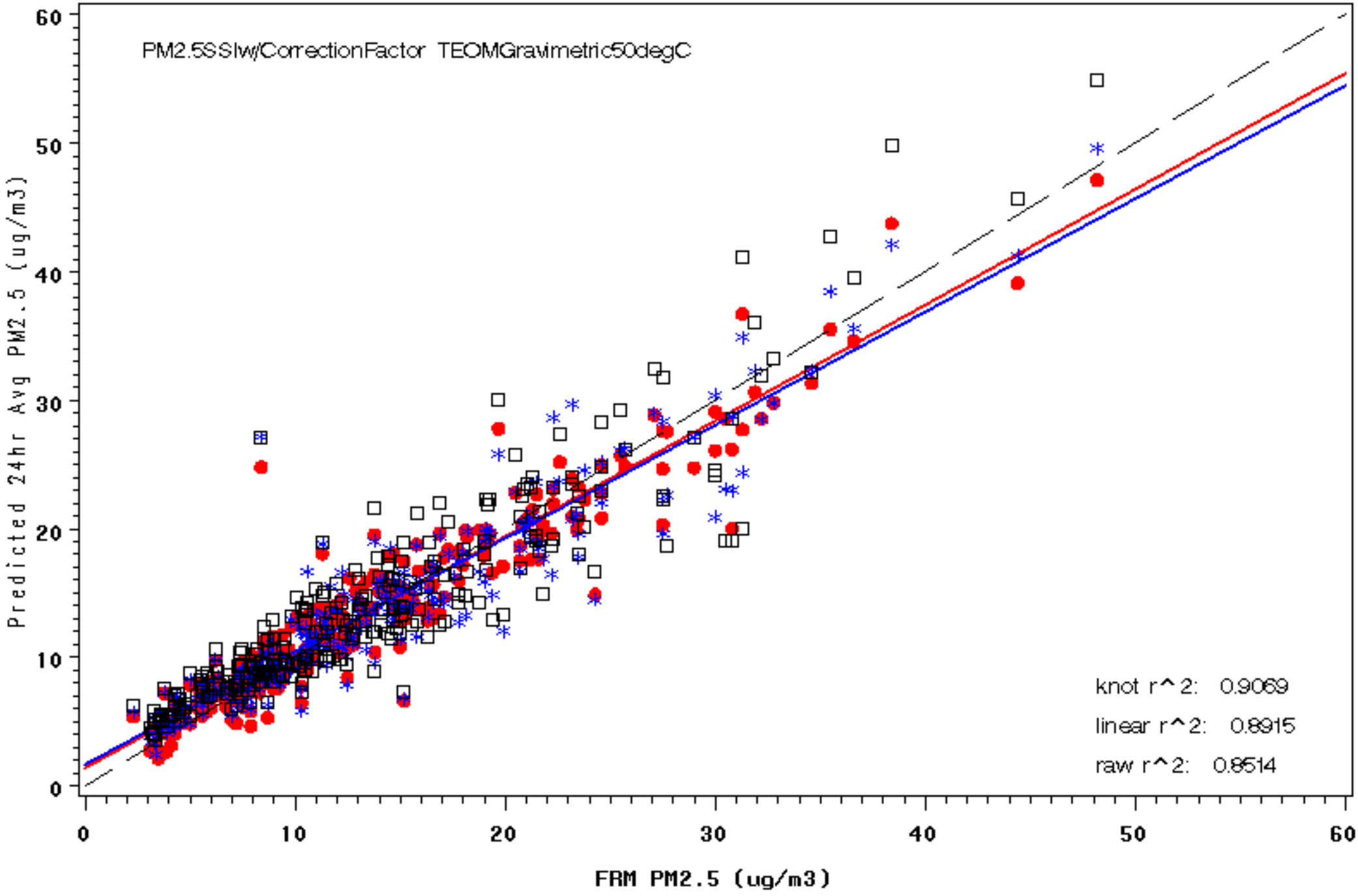
Results
Seasonal Linear Model

- R^2 comparable to "Knot" model
- Surrogate for temperature in "Knot" model
- Disadvantage
  - Changes in season from fitting data change relationship between FRM and continuous measurement

Examples of Model Fits Using Data Models Constructed From

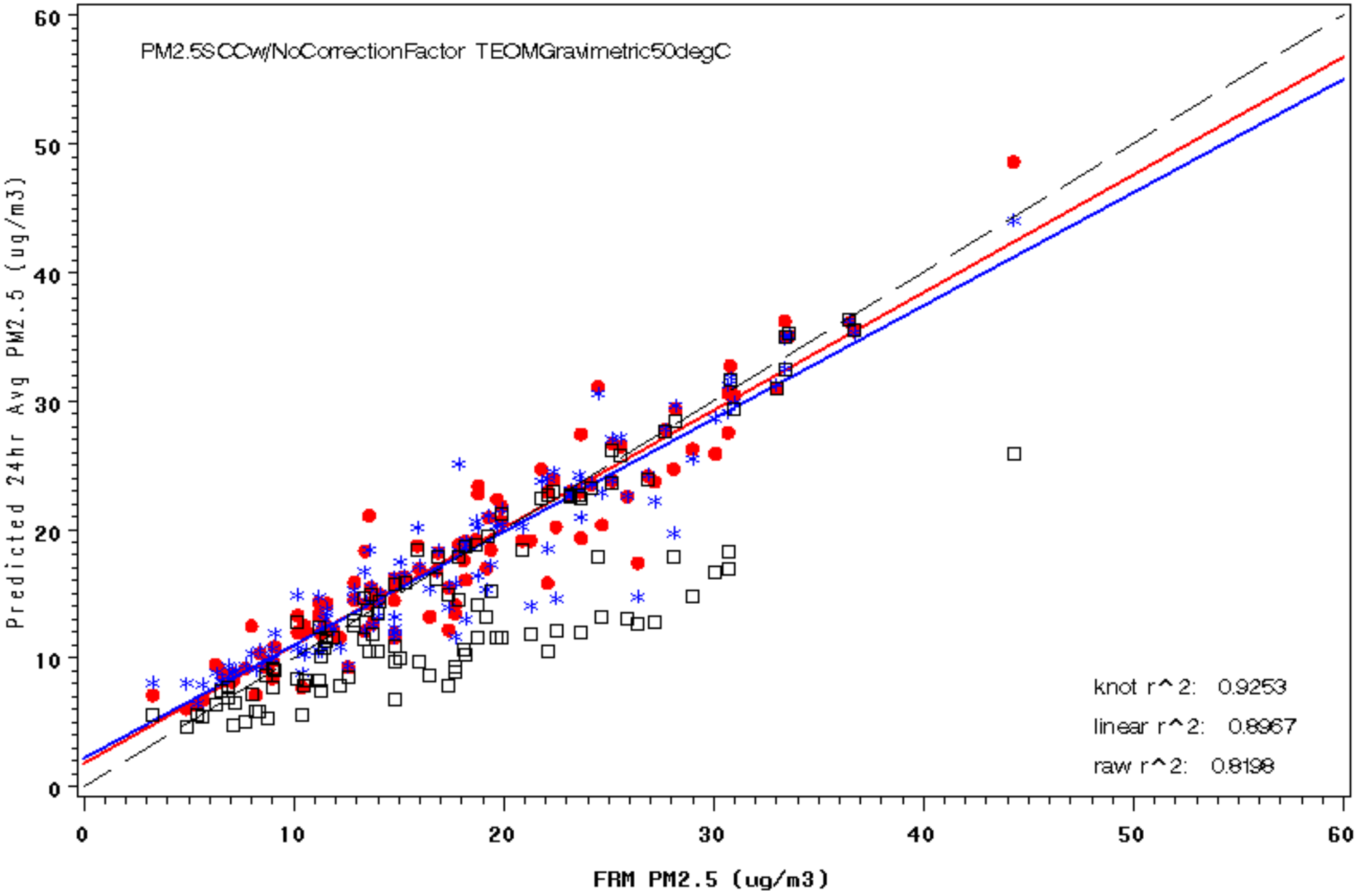
NEW YORK CITY, NY

360810124881013



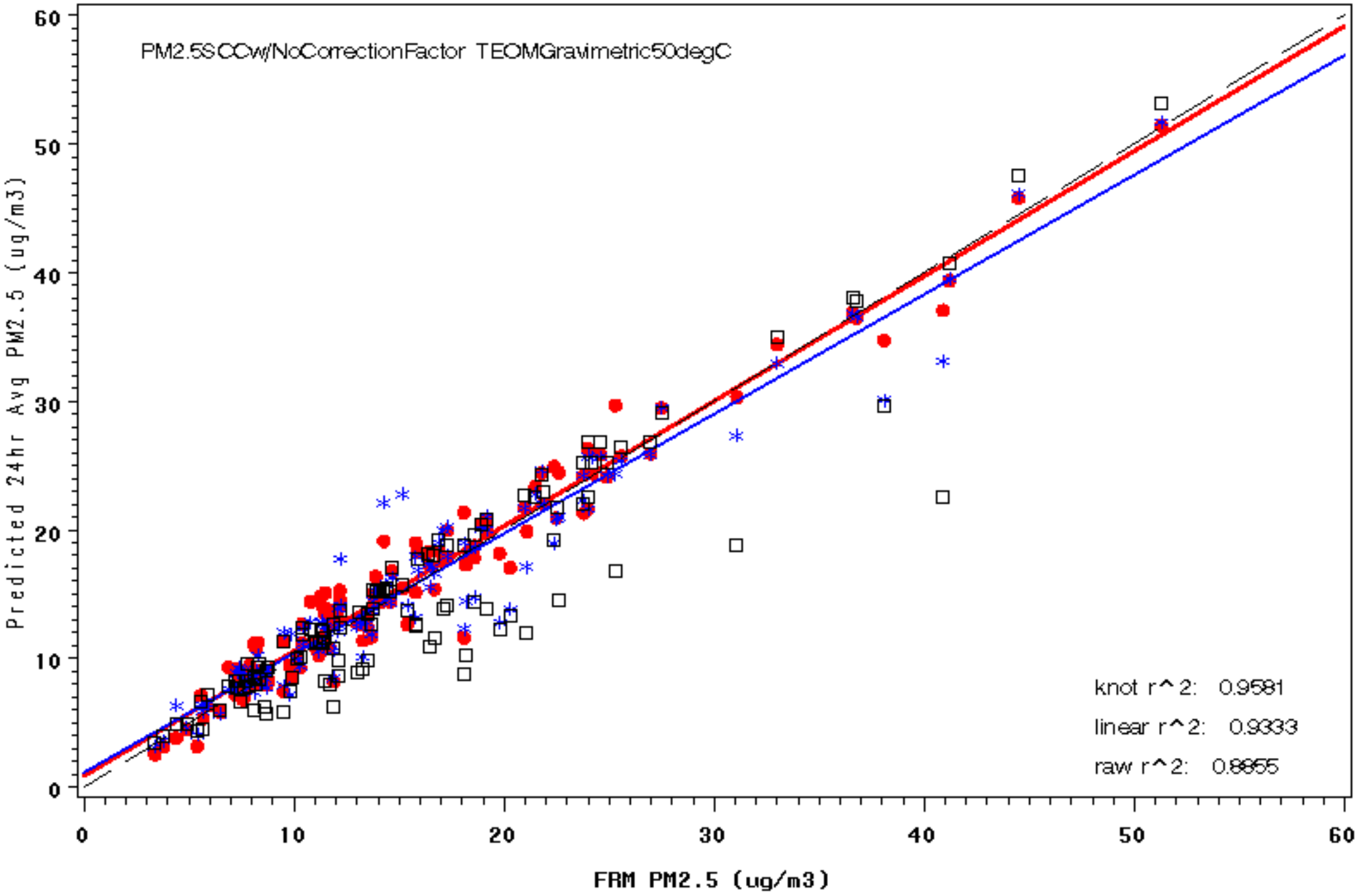
INDIANAPOLIS, IN

180970078881013



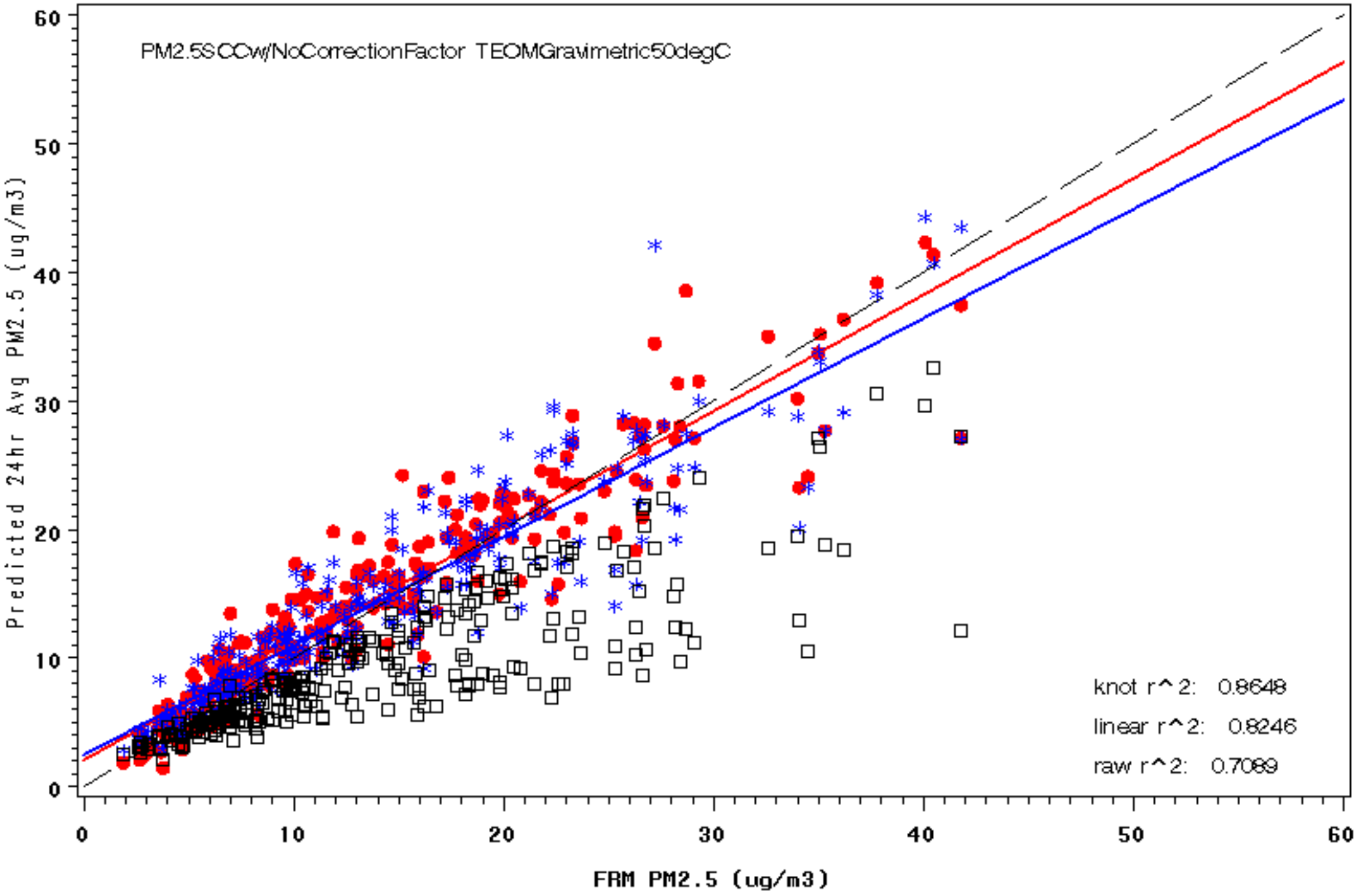
CINCINNATI, OH

390610040881013



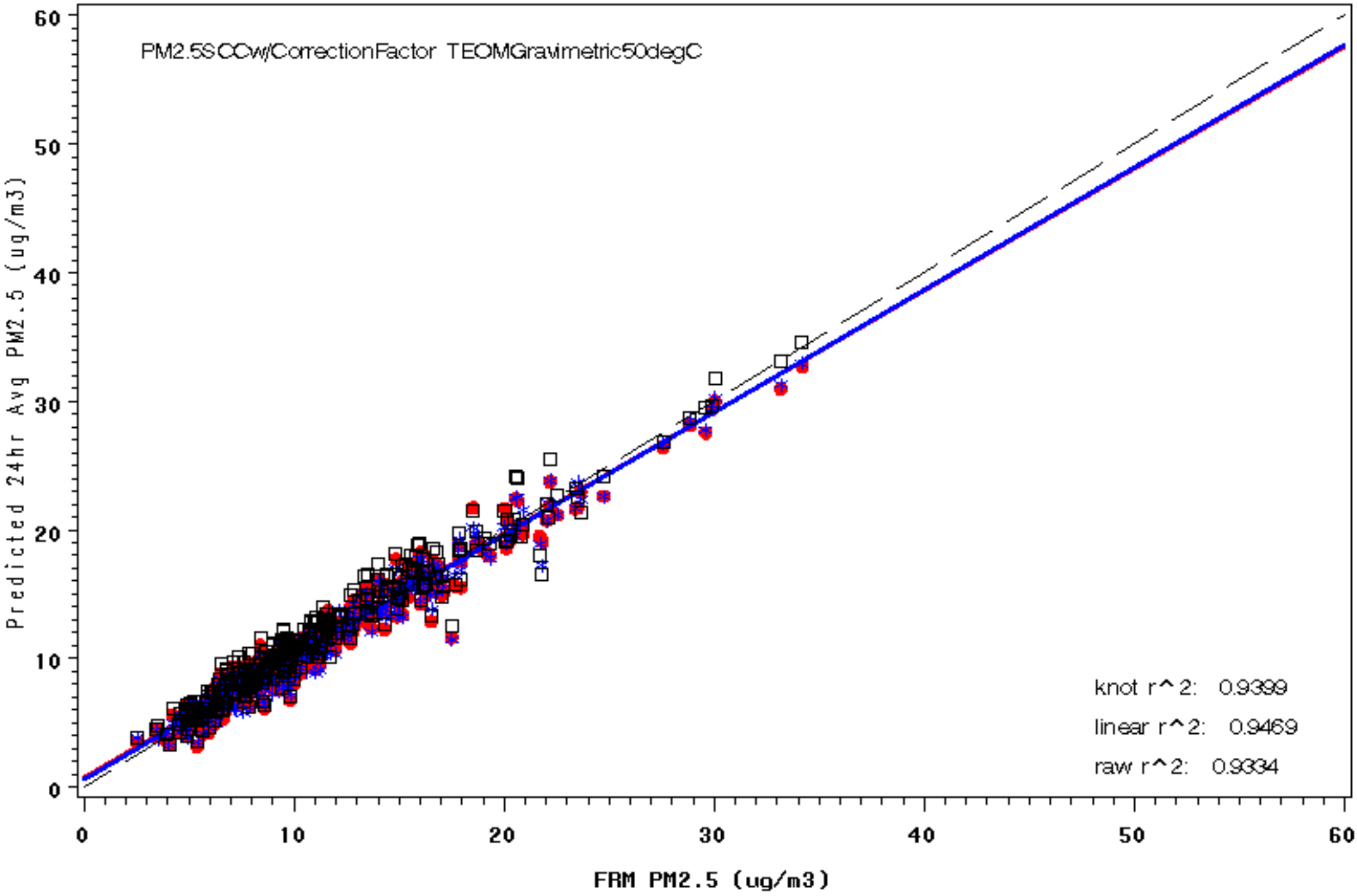
GRAND RAPIDS, MI

260810020881013



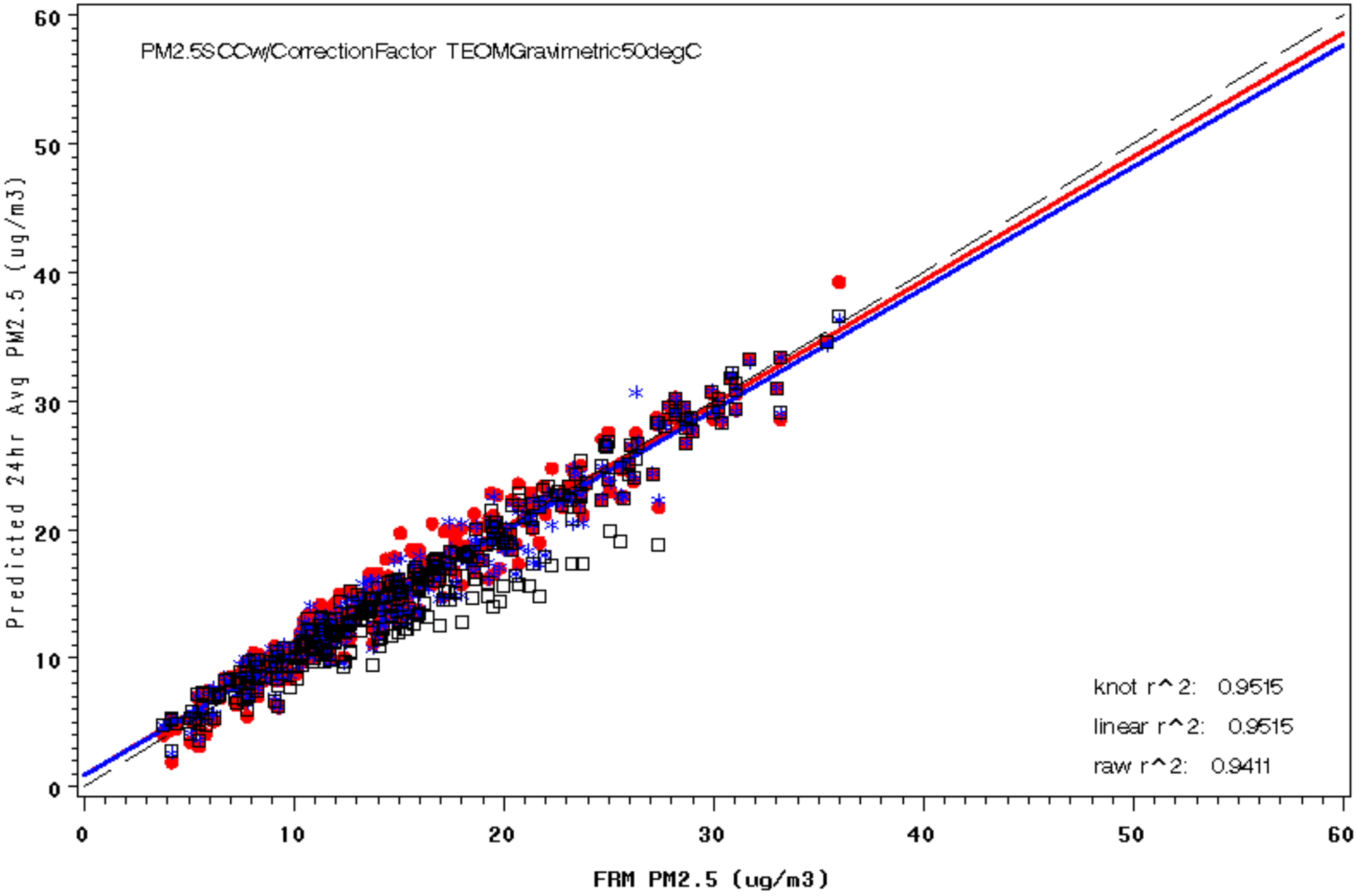
ST PETERSBURG, FL

121030018881013



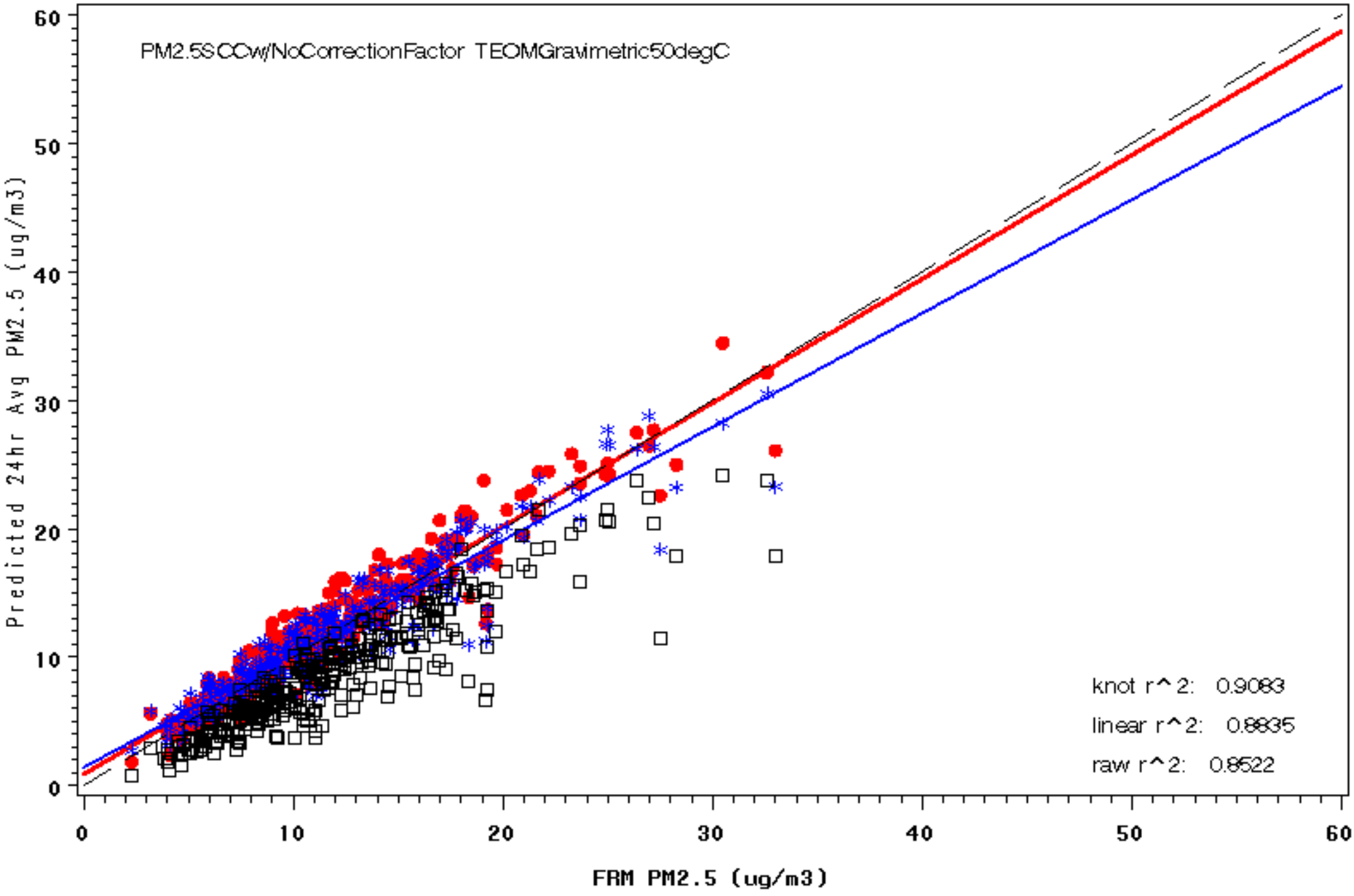
CHARLOTTE, NC

371190041881013



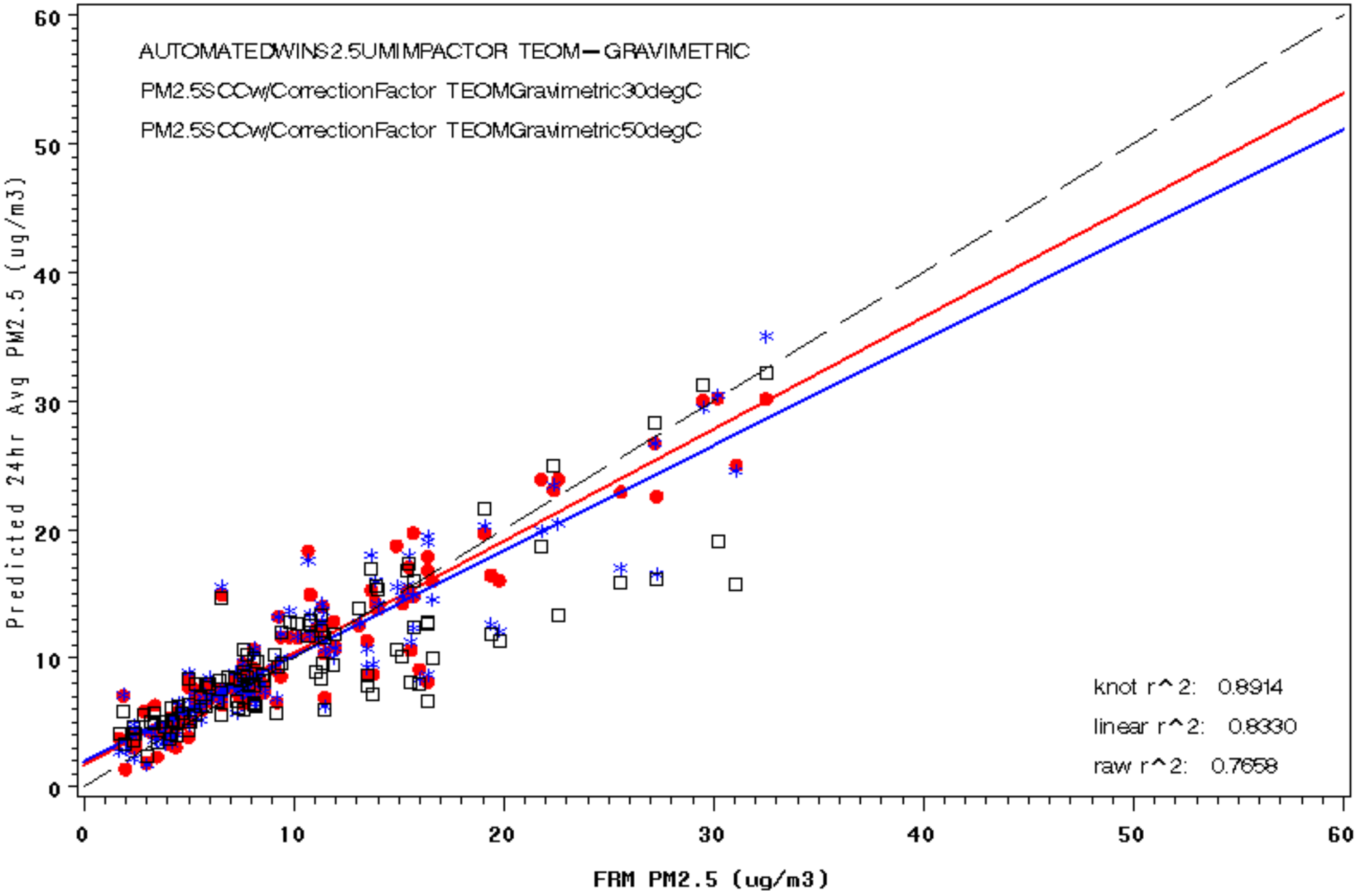
FORT WORTH, TX

484391006881013



KEOSAUQUA, IA

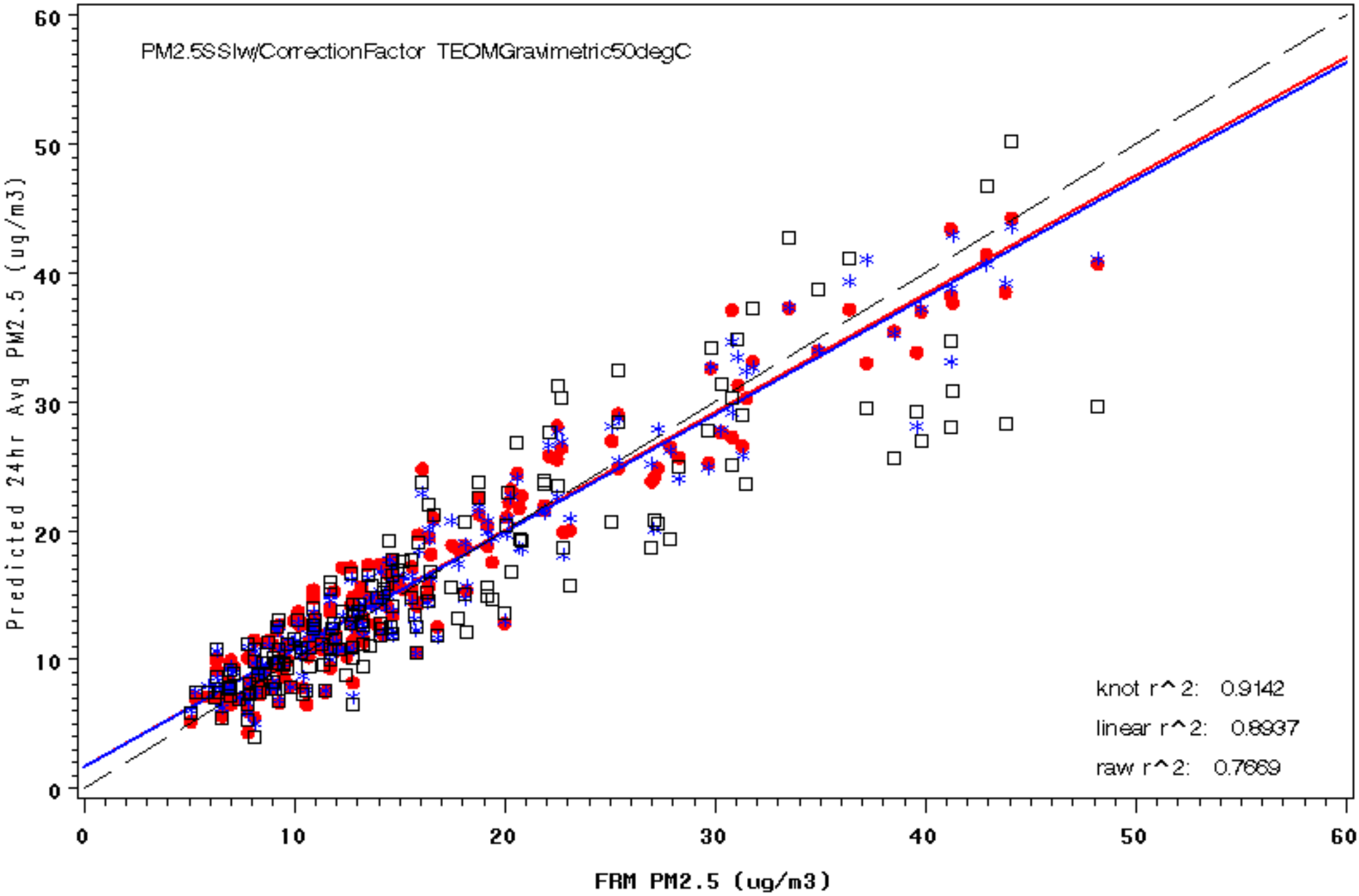
191770005881012



Examples of Validation Using "Extra" Data

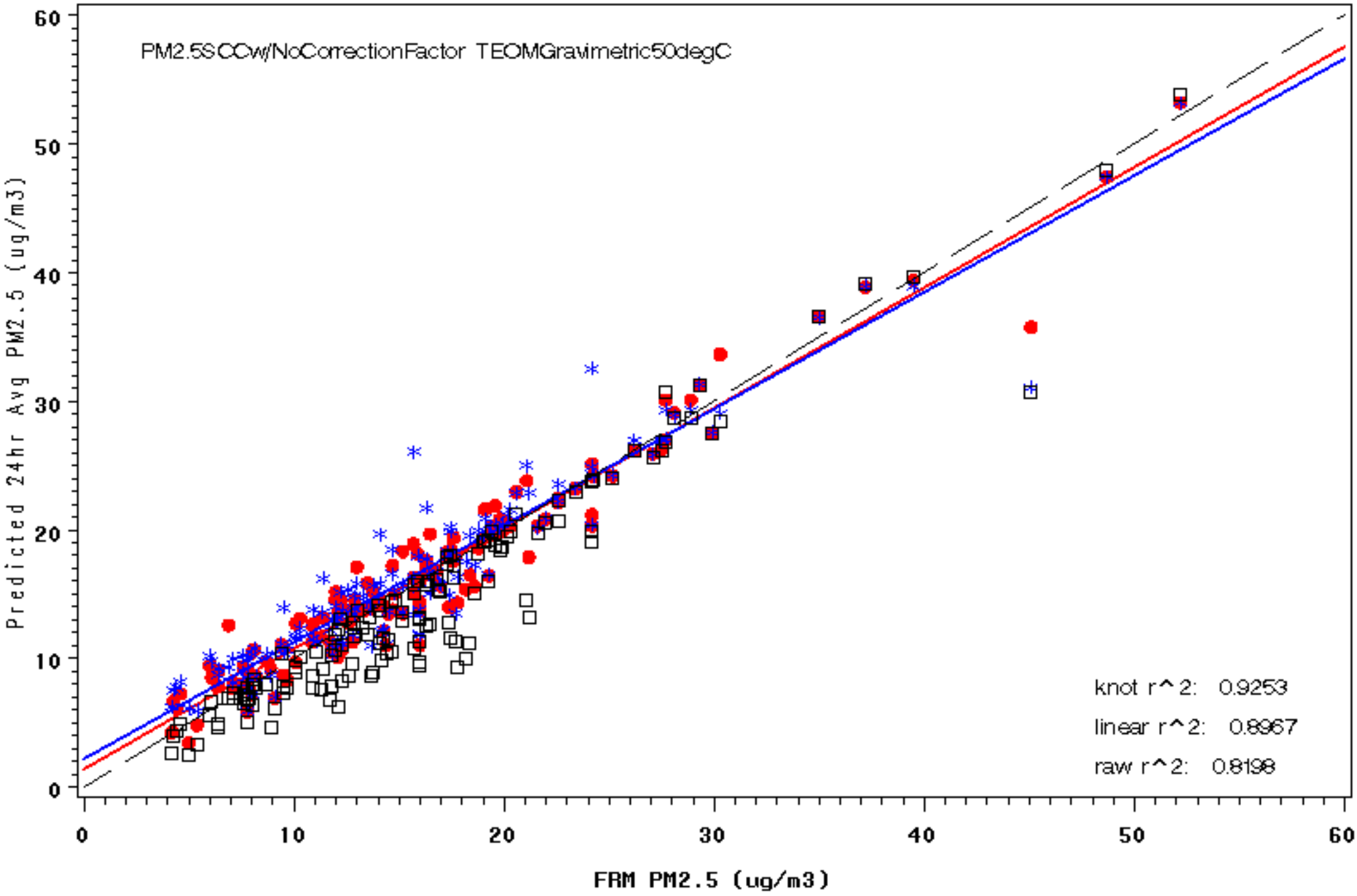
NEW YORK CITY, NY

360610010881013



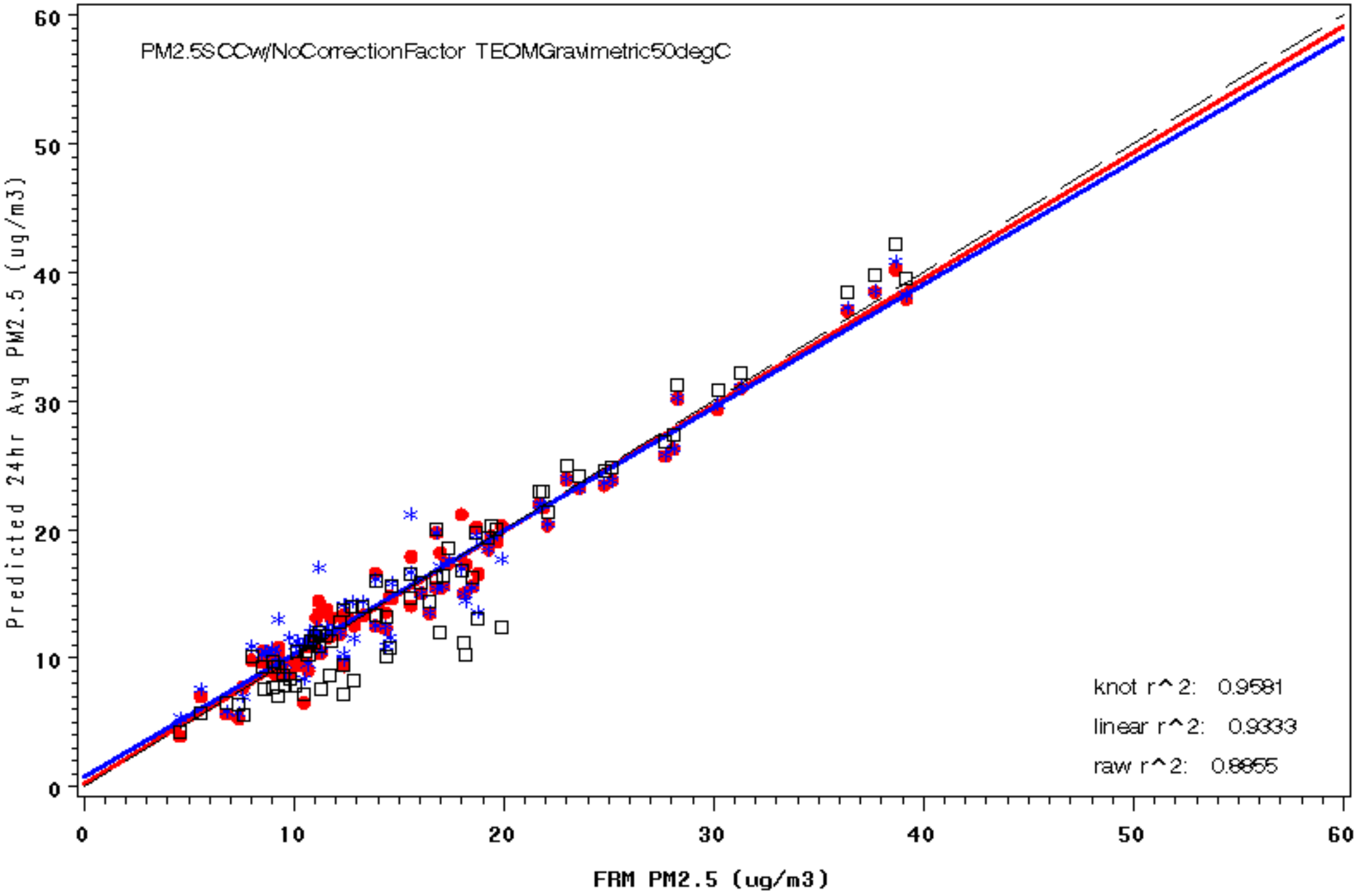
INDIANAPOLIS, IN

180970078881013



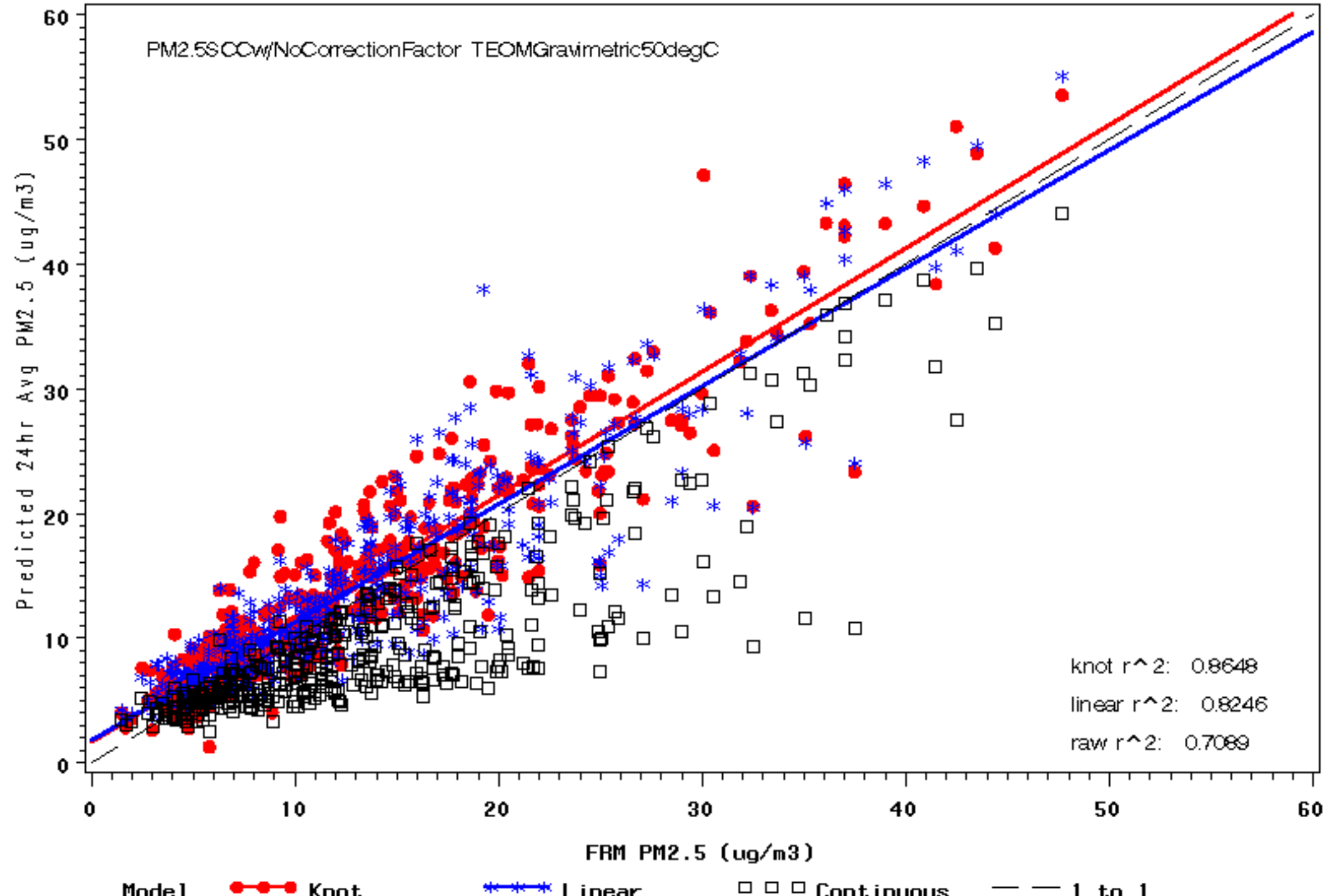
CINCINNATI, OH

390610040881013



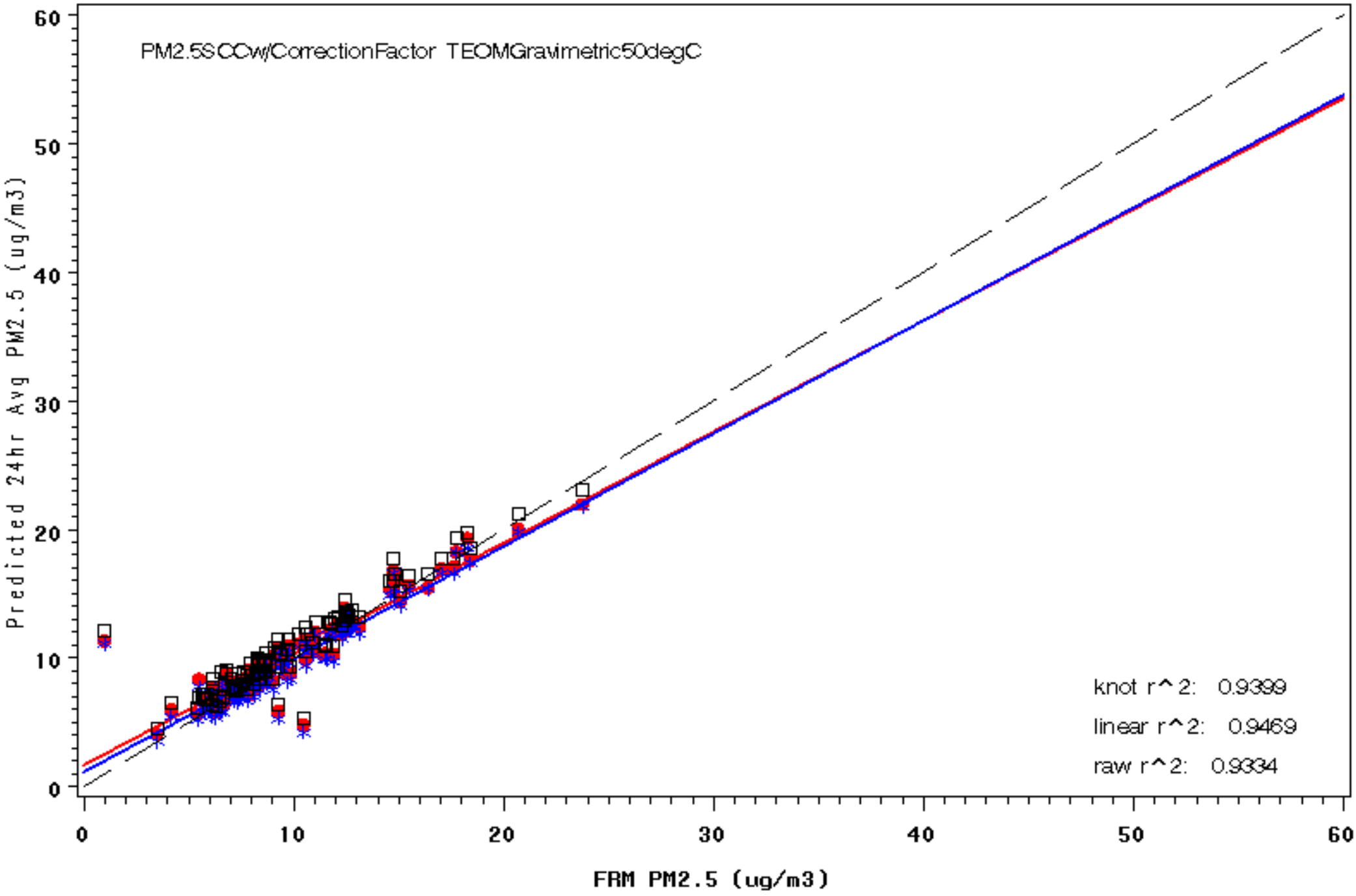
GRAND RAPIDS, MI

260810020881013



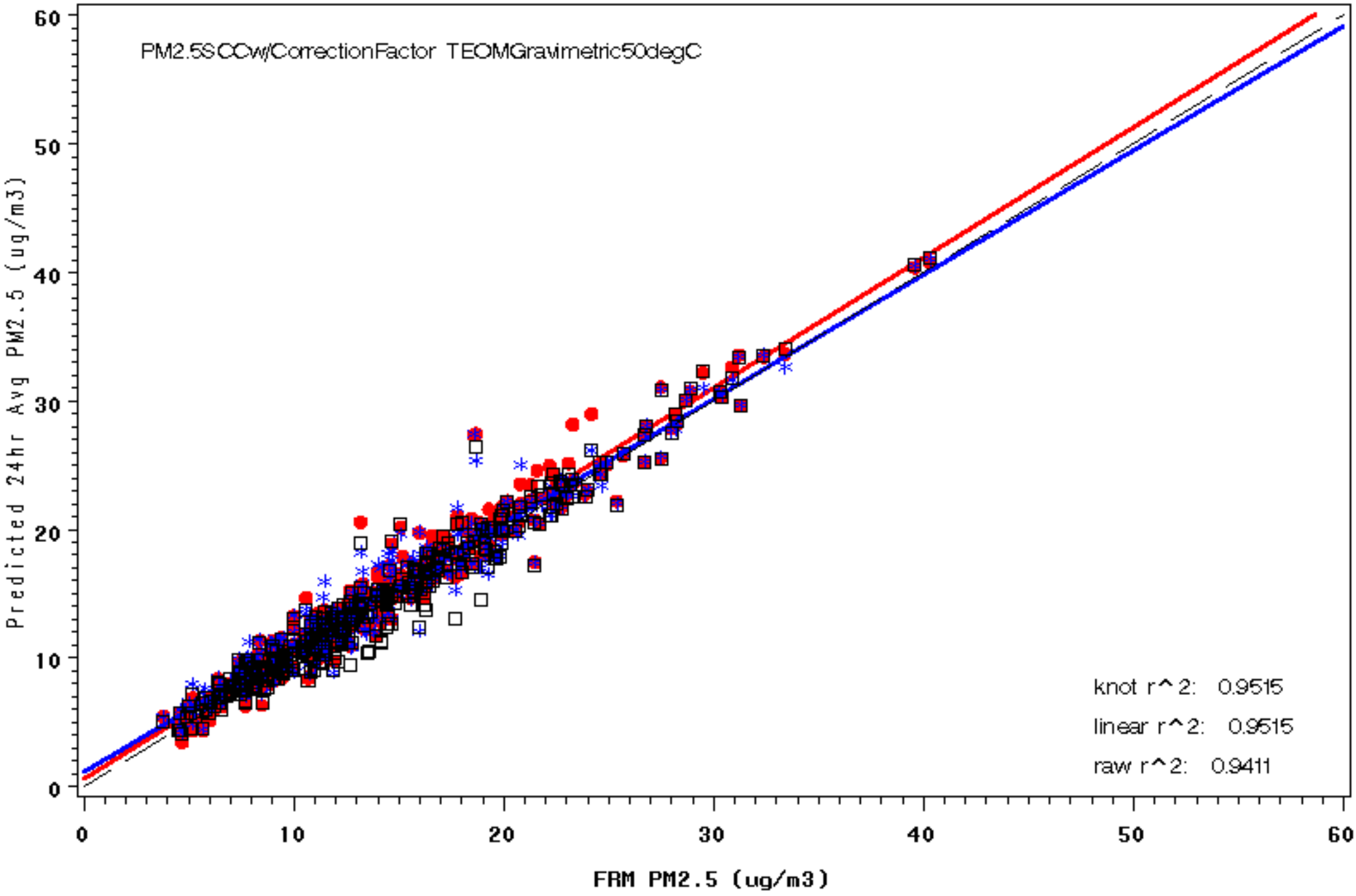
ST PETERSBURG, FL

121030018881013



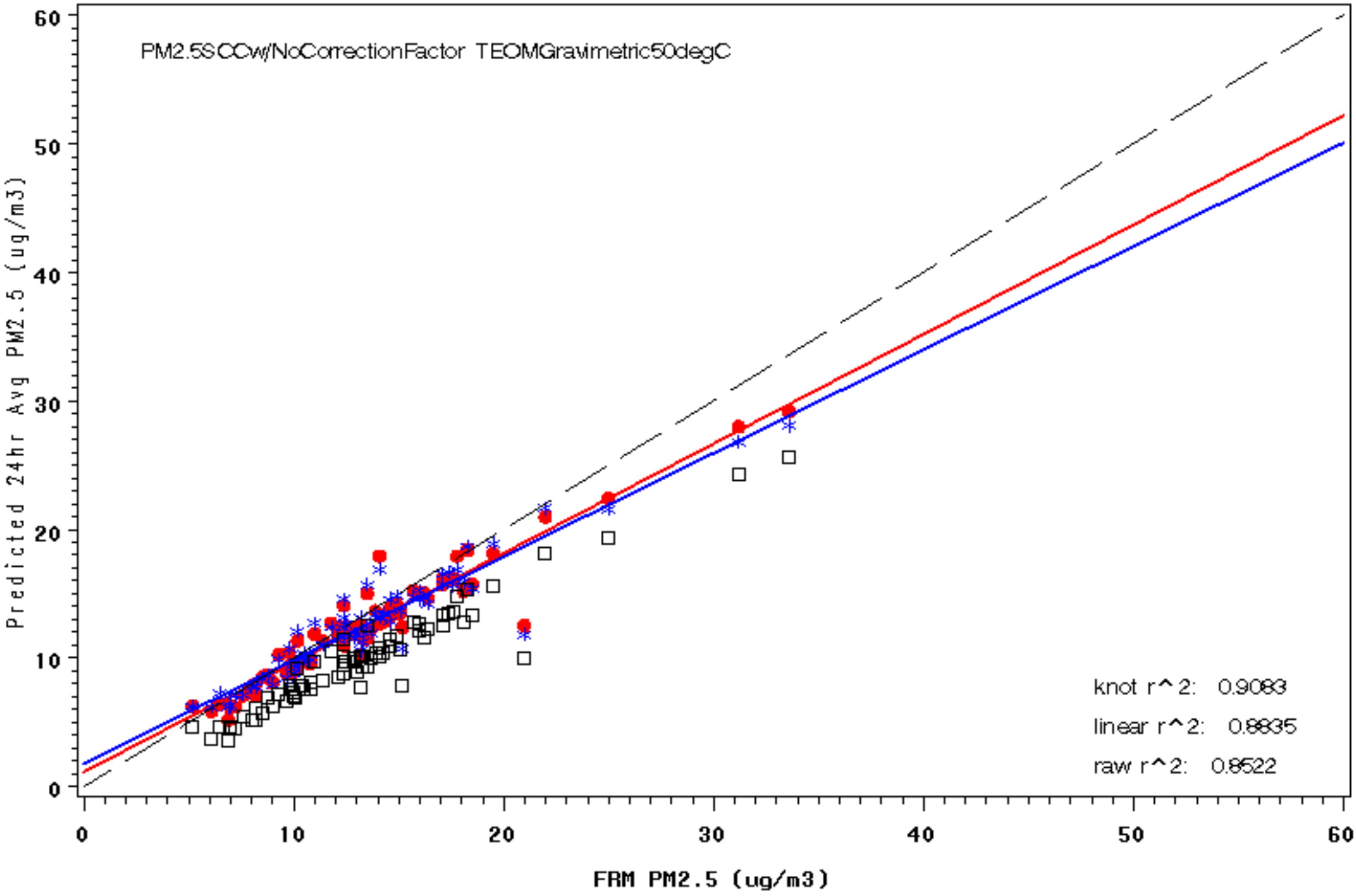
CHARLOTTE, NC

371190041881013



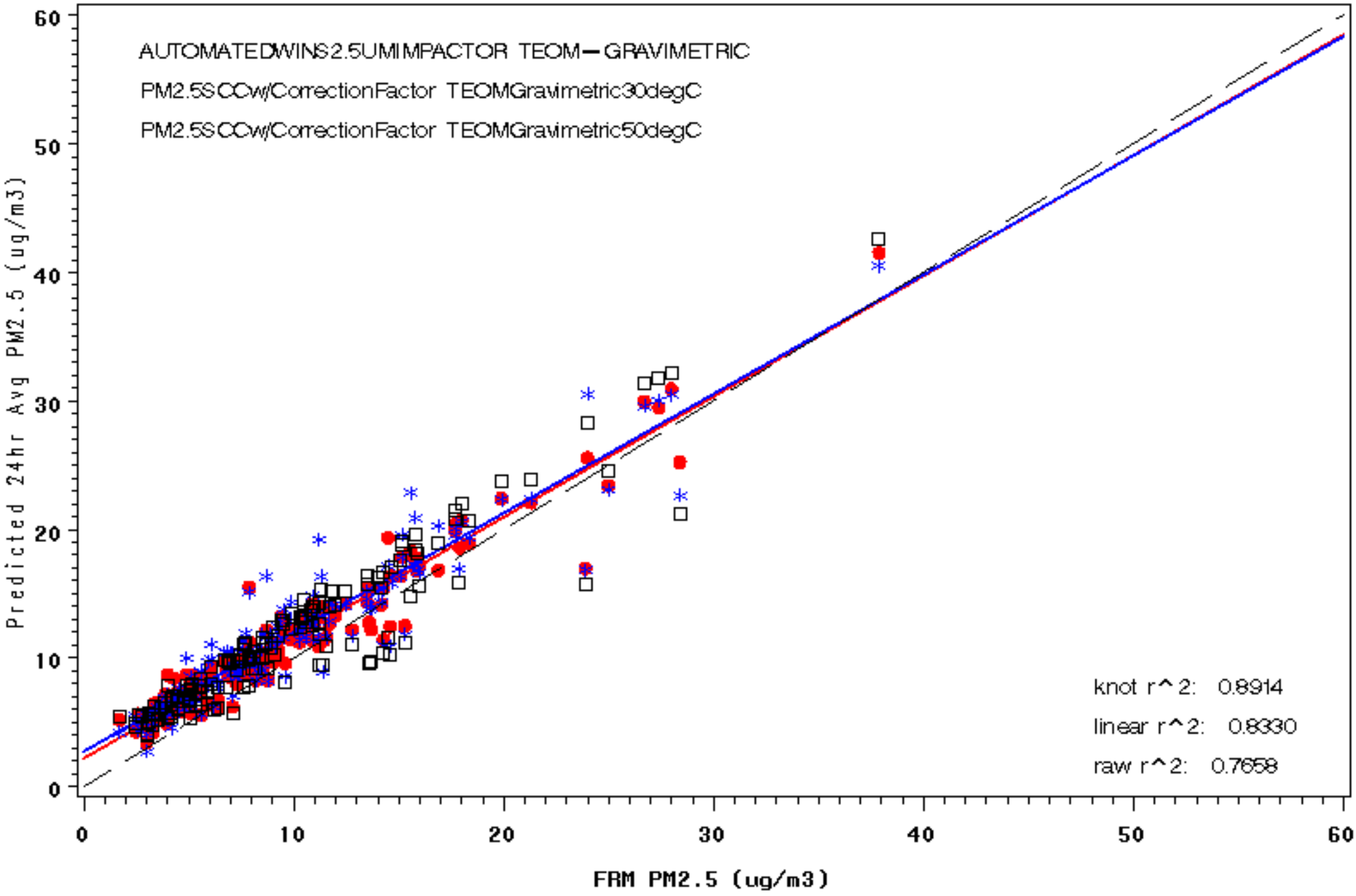
FORT WORTH, TX

484391006881013

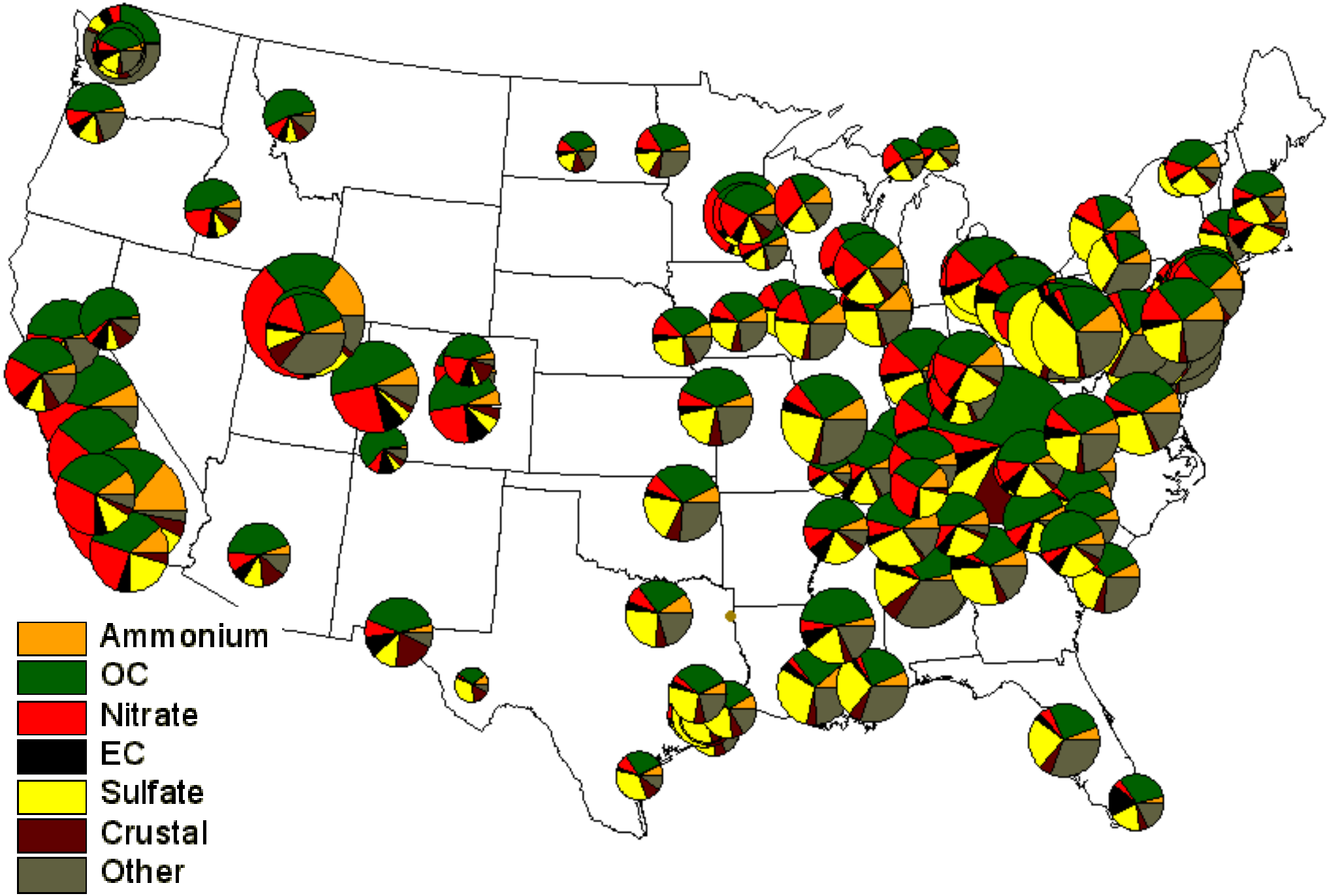


KEOSAUQUA, IA

191770005881012



2001 Fine Particulate Speciation Concentrations



Conclusions

- "Knot" and seasonal linear method satisfy DQO requirements
- Some sort of seasonal adjustment necessary in areas with nitrate problem
- "Knot" and seasonally adjusted linear models comparable
  - Linear model surrogate for "Knot" model
- Uncertainty about seasonally adjusted linear model under changing conditions

Conclusions

- Need for more data
  - Other monitoring technologies
  - Validation purposes
- Need for consistent national operating procedures across methodologies is **ESSENTIAL**
- Statistical transformation is temporary solution
  - Need technological solution implemented consistently across country
    - No change in data by use of various transformations across States
    - Better ensures data consistency and quality across States